Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

MICROCYCAS CALOCOMA

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY XCVII

OTIS W. CALDWELL

(WITH PLATES X–XIII AND FOURTEEN FIGURES)

In a recent number of the BOTANICAL GAZETTE (1) there appeared a brief taxonomic account of this plant. It was described originally by MIQUEL, from fragmentary material, as *Zamia calocoma* (2), although on account of its resemblance to a small *Cycas revoluta* he made for it the section Microcycas under Zamia. Later DECANDOLLE (3) added to MIQUEL'S description and raised the section to generic rank. The previous paper (1) added to the knowledge of the taxonomic features of the species; while the present paper deals with the field studies and the morphology.

FIELD OBSERVATIONS

The region in which this study was made is in the Sierras of western Cuba, beginning with the mountains northwest of San Diego de los Baños, running through the Santa Catalina region, and ending to the westward with the mountain known locally as Cuchillo de Pinar, near San Andrace. Within this area Microcycas was found in four places, in three of which the plants were few and distinctly local. In the other (Cuchillo de Pinar) the plants were found one, two, or a half-dozen together at infrequent intervals for a distance of one and a half to two miles along the mountain. It is highly probable that sufficient search would result in the discovery of other groups in other mountains. The native Cuban mountaineers, to some of whom the plant is known as "palma corcho," reported that they had heard of the plant elsewhere, though they said it is extremely rare. The folk-lore of the region says that the roots of the "palma corcho" are good for use as rat poison, hence the desirability of a knowledge of its location, and the probability that there would be knowledge of any large groups of individuals should they exist.

The specimens observed were not confined to any particular exposure; the one shown in *fig. 3* is facing south; those in *figs. 1, 2,* and *4* are facing north; while those in *figs. 5* and *6* face west. In so far as could be determined, the plants are closely limited in elevation, the level showing them to be at essentially the same elevation though they vary greatly in their distances from the tops of the mountains upon which they grow. They were found growing on limestone, in places almost devoid of soil (*fig. 2*), in rocky soil (*fig. 3*), and in clay (*figs. 1, 4–6, 9*).

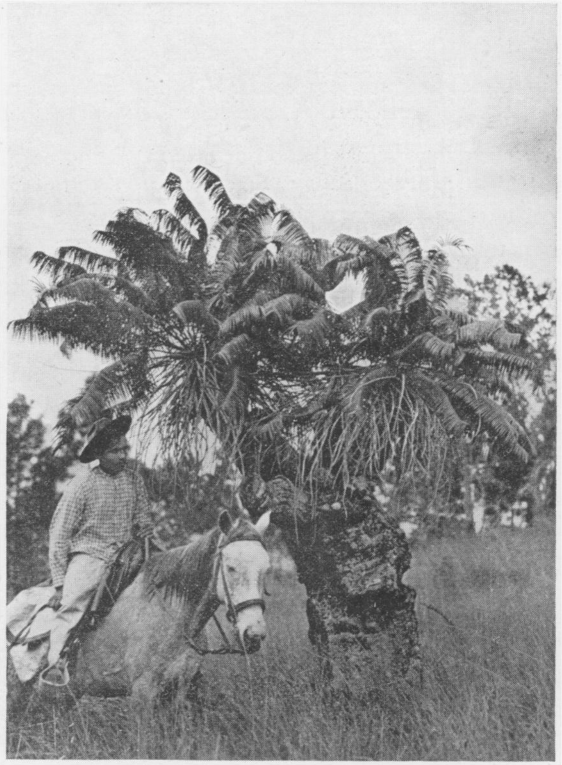


FIG. 1.—A plant 2^m in circumference at 1^m above ground; no other plants in this vicinity.

The roots show considerable ability to adjust themselves. In clay they sink deep into the soil, the stem and root system, in the case of younger plants, suggesting the geophilous habit of some of the Zamias. The plant shown in *fig. 9* was imbedded to within 3.75^{cm} of the top of the stem. This plant is 9.5^{cm} in diameter and is doubtless a good many years old, though relatively young. The geophilous habit is relatively temporary. As the plant becomes older its stem elongates, and at one period in this advance (*fig. 7*) the whole plant bears a marked resemblance to *Cycas revoluta*. The continued elongation of the stem results, at least in the case of those specimens that grow surrounded by taller plants of other species, in producing stems several meters in height (*figs. 2, 3, 4, 6*), the specimen at the right in *fig. 4* (showing neither base nor crown) being 9.5^{m} in length. The plants shown in *figs. 1* and *3* are doubtless the oldest plants observed. Both of these grow in the open and it seems not unlikely that they were once much taller than now, that they were injured by winds or otherwise, and that the branches now bearing leaves originated from dormant buds relatively late in the history of these individual plants. Evidence favoring such an interpretation is found in the facts that the terminal bud region of both these plants, and all similar ones observed, is injured and partially decayed; that the central starchy pith region of Microcycas is extremely brittle and would be easily broken if exposed to very heavy winds; and that many cases were observed of new branches arising from the surface of the plant body. One case was observed in which the young branch formed roots which penetrated the main body of the parent plant. Specimens of younger plants were found in the open, in which there was a single terminal crown of leaves, but none nearly so old as those shown in *figs. 1* and *3*. It may be that, if undisturbed, these would develop stems as old and thick and not attain greater height; but this does not seem probable.

The stem may be straight and unbranched (*figs. 2, 8*), or it may branch in a number of ways. In *fig. 4* is shown a group of four plants which arise from the stump of an older one. The decayed remains of the old stump, though not evident in the photograph, were observed, and showed clearly that the branches arose from the old stump below the surface of the ground. Other illustrations of branching are shown in *figs. 1, 3, 4, 6*.

Upon the surface of the stem of all younger plants, as well as upon

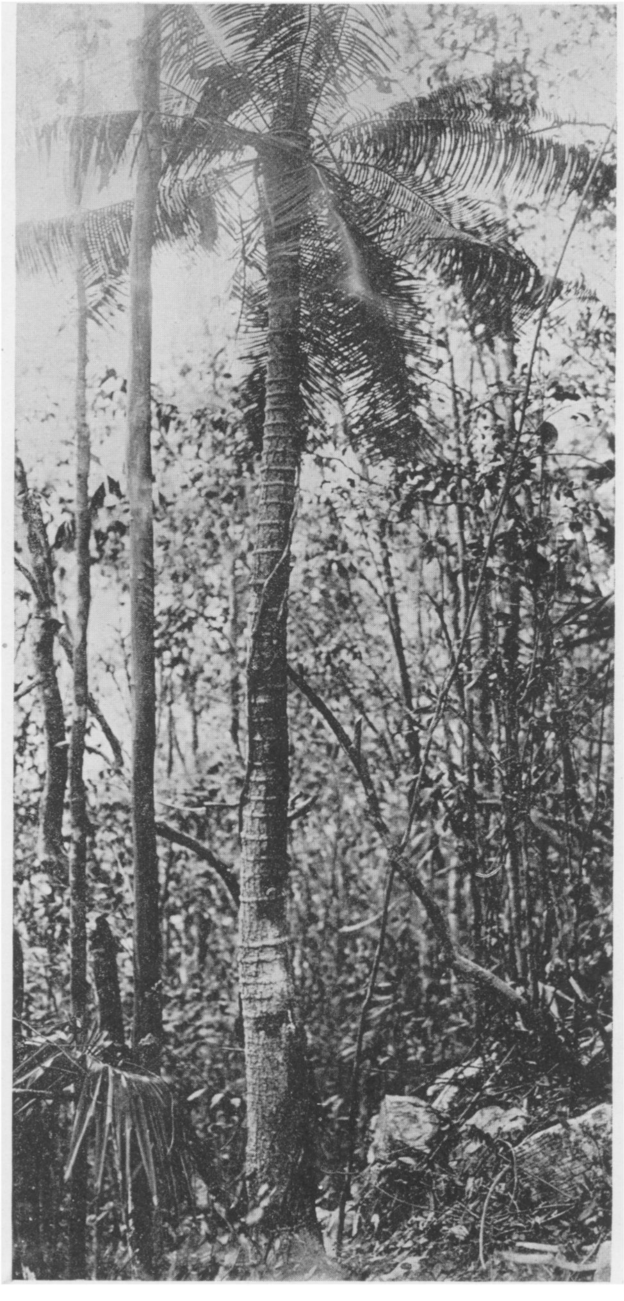


FIG. 2.—A type growing in densely shaded regions; this specimen is growing on the northern slope of a steep rocky mountain.

older ones of the shaded forms, may be seen rings of the cortex and bark which indicate the position of former terminal buds (*figs. 2, 4, 5, 6, 8*). Just what these may signify relative to age has not been determined. It may be that they are formed only by the foliage buds, or only from scale buds, or even possibly from reproductive buds, or all of these put together. It is not known how often a new crown of scales, or of foliage leaves, or of reproductive structures is formed in Microcycas. These rings may persist until the plant is quite old (*fig. 4*), or may disappear entirely and give place to a bark-formation quite resembling that of the trunk of some pines (*fig. 3*). In nearly all older plants at the base of the stem will be seen such bark-formation as shown in the figure just cited, while at some point above the characteristic rings appear. Were these characteristics not found upon the same stem, one could readily believe that the stems shown in *figs. 2* and *3* do not belong to the same species.

The details of anatomy of the stem have not been investigated. From a gross examination it is evident, however, that Microcycas has a single vascular cylinder surrounded by a thick cortex and enclosing a large pith region (*fig. 10*), as in Zamia, Dioon, and Stangeria. The pith is extremely brittle, and its cells are densely filled with very large starch grains.

The leaves, which often exceed a meter in length, vary greatly in the number in each crown (*figs. 1–8*). The length of life of a leaf could not be determined, and although no leaves upon old plants were found opening from the bud, the vernation in seedlings is circinate.

OVULATE CONES AND MEGASPORANGIA

A single ovulate cone (*fig. 8*) was found on a number of plants. It appears upon first observation to be a terminal structure, but closer investigation indicates that it is lateral, though younger material must be studied to determine definitely this point. The base of the cone is enclosed by heavy, hairy scales (*figs. 11, 12*) which usually have their upper ends pressed closely between the outer portions of the basal sporophylls. The cone shown in *fig. 8* was 94^{cm} from the center of its base to the center of its tip, and weighed 9.5^{kg}, being the largest cycad cone yet reported. This one, however, appears to be slightly larger than the average ovulate cone of Microcycas.

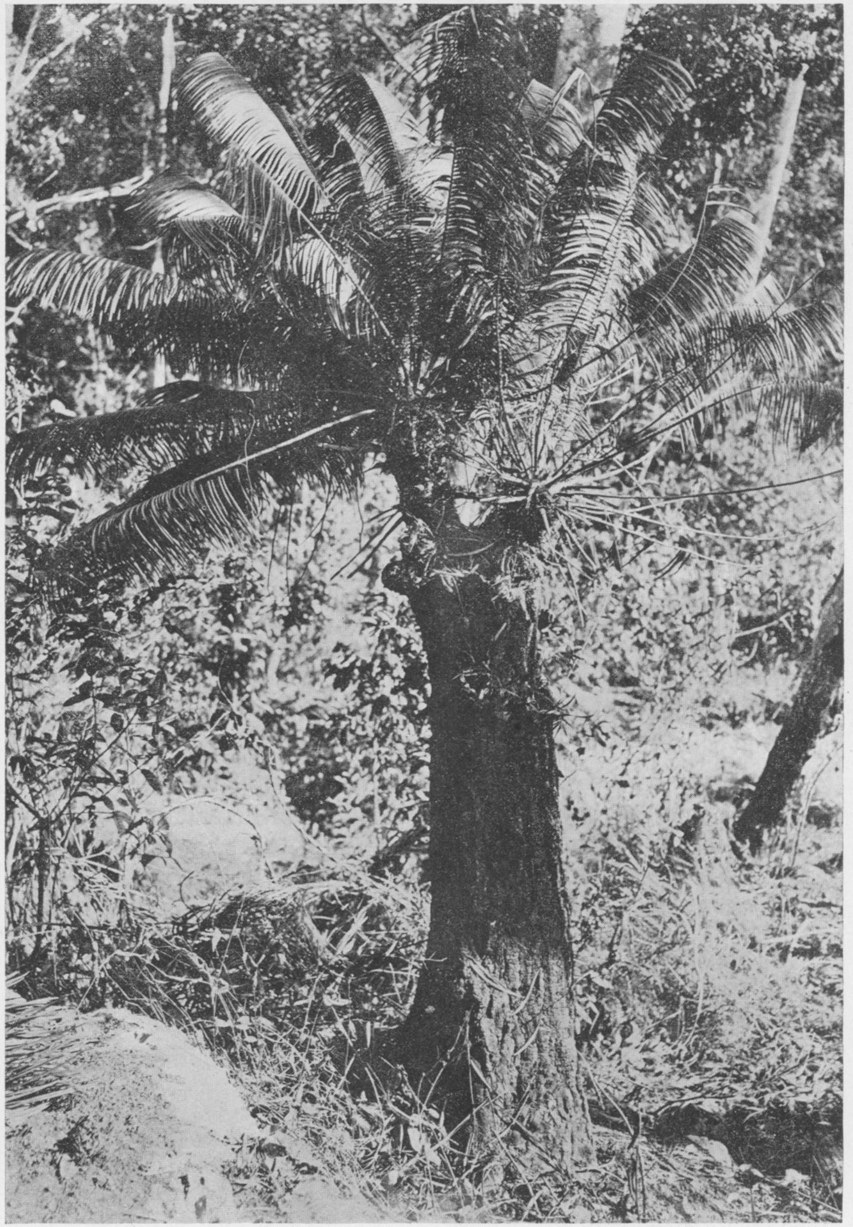


FIG. 3.—An old plant with numerous branches; rings about the stem have disappeared, and ridged bark is present.

In cones of the ages shown in the figures the sporophylls are closely pressed together, and are covered over the exposed portion by a dense mass of closely appressed grayish hairs. At the time of seed distribution the sporophylls separate, the entire cone bends on its stem, and is pendent from the apex of the plant. The individual sporophylls bear some resemblance to those of Zamia, but are specifically distinct. The outer portion is drawn out into an obtuse point, upon which are two ridges.

Most of the cones are quite symmetrical and are remarkably well rounded both at base and tip, thus suggesting complete pollination and development of sporangia (*figs. 8, 11, 12*). In some cases this is not true, and irregularities suggesting imperfect pollination are conspicuous. To the left in *fig. 11* such a cone is shown.

Each sporophyll bears two sporangia of a peculiar salmon-pink color. These sporangia in the mature cones are closely crowded together (*fig. 12*), thus producing the corklike form of the seed from which is derived the Cuban name "palma corcho." The integument of the ovule is differentiated into an outer fleshy layer; a thin, hard, brown layer; and an inner fleshy layer which becomes thin and papery. Vascular bundles pass up the stalk of the megasporophyll, anastomose in the upper portion, and give off five to eight branches which pass into each ovule. Just after entering the base of the ovule each vascular bundle forms two branches, one of which traverses unbranched the outer fleshy layer; the other enters the hard coat and divides into a large number of anastomosing branches (*fig. 16*).

STAMINATE CONE AND MICROSPORANGIA

Although the staminate cones had formed and shed their pollen some months before they were obtained, one entire cone and fragments of several others were found. It is likely that the entire cone shown in *fig. 13* was delayed in development and did not mature its pollen normally, since all the other staminate cones are pendent and had their stamens separated by elongation of the cone axis. From the material collected it would seem that the staminate cone is $25–30^{cm}$ long and $5–8^{cm}$ thick. Its position on the tip of the stem indicates that it is lateral in origin.

The microsporophyll has its outer portion expanded, and spo-

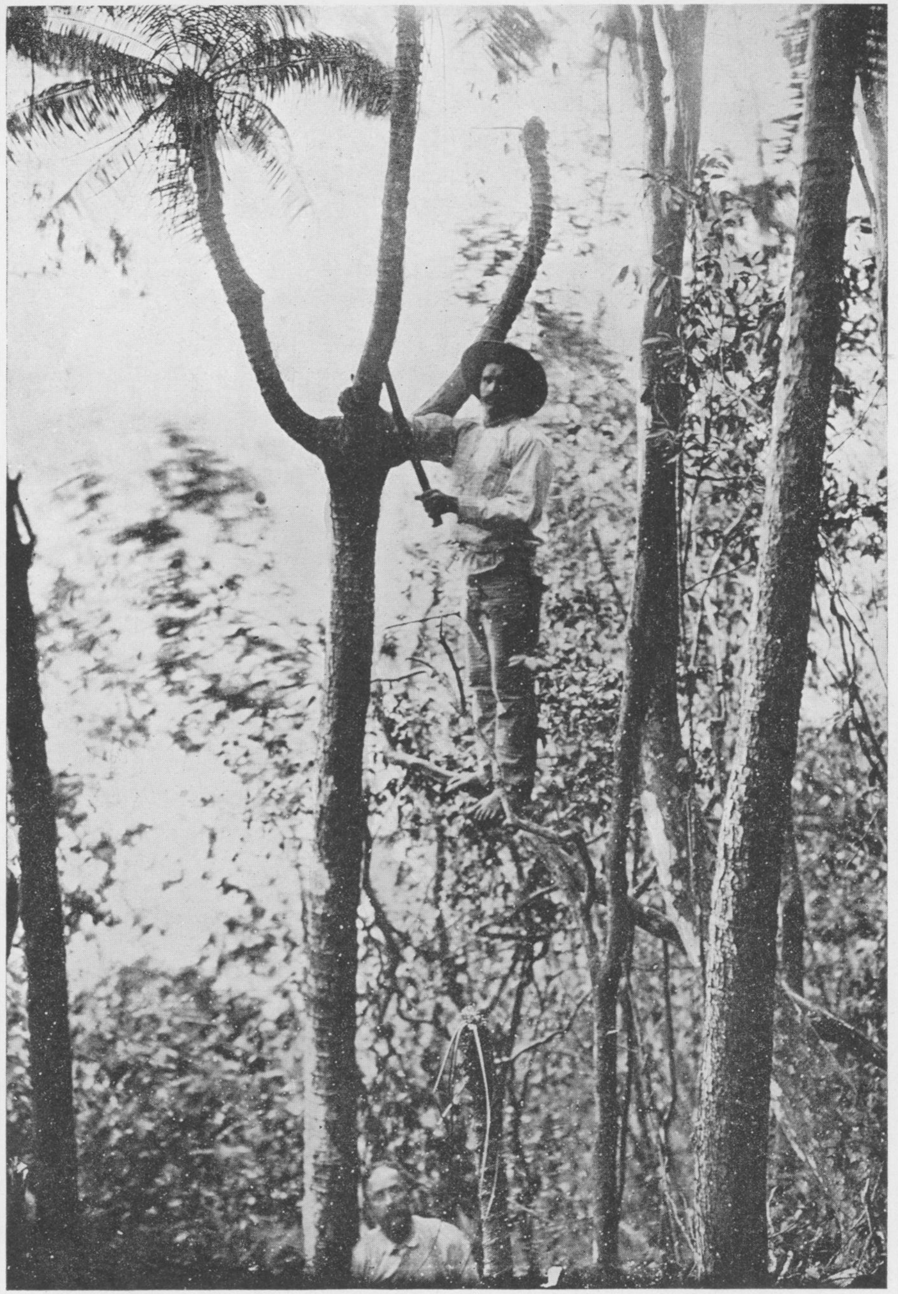


FIG. 4.—Three plants; large one at right (9.5^m high) showing neither crown nor base; in the middle a small plant showing terminal bud and two or three old leaf stalks; at left a branching plant, the height of which is suggested by the two men, one of whom is standing at the base of the tree.

rangia entirely cover the basal two-thirds of the abaxial surface (*fig. 14*). They are not arranged in sori and cover the basal and apical sporophylls as completely as they do those in the middle of the cone. The sporangium dehisces by a long slit which extends almost to its base. The microspores are spherical, with a moderately heavy exine and a quite prominent intine.

MALE GAMETOPHYTE AND SPERMS

None of the pollen collected could be made to germinate, possibly due to its age and to the fact that a fungus was growing in the material when collected.

In the earliest stages shown by the material, the male gametophyte is already well developed (*fig. 15*). After the microspore reaches the pollen chamber, the pollen tube grows upward and outward into the nucellus. The relation of this growth in time to the development of the structures within the tube could not be determined. In pollen tubes at this stage there are usually a tube nucleus, a prothallial cell, a stalk cell, and eight body cells (*figs. 17, 18*). The tube nucleus is usually near the tip of the tube (*figs. 18, 19*), but sometimes behind some of the body cells (*fig. 15*). Most of the body cells remain near the base of the pollen tube, though some are usually near its tip. While the number of body cells is most frequently eight, it varies to nine (*fig. 20*), ten (*fig. 19*), and possibly more. Several illustrations of such variation were found.

The prothallial cell extends into the stalk cell (*figs. 17–20*), as described by WEBBER (6) in Zamia. At the base of the prothallial cell there may be seen sometimes a darkly staining mass which may possibly be the remnant of a first prothallial cell (*figs. 19, 20*).

In the youngest body cell observed the two blepharoplasts are well organized, each with numerous radiating lines of cytoplasm which extend well down toward the equator of the cell (*fig. 21*). The nucleus is sometimes irregular in form, as if its membrane in places were being pushed inward by the cytoplasmic radiations. When the nucleus varies from the spherical form, it is more or less flattened at right angles to the lines of radiating cytoplasm (*figs. 17–20, 21, 47*). At this stage the blepharoplasts are usually opposite each other, and the entire cell presents a beautiful symmetrically arranged spherical figure. A few cases were observed in which the blepharoplasts were near each other (*figs. 22, 23*), and one case in which they were in contact (*fig. 24*); a careful search failed to show other blepharoplasts. WEBBER figures similar cases, except he found none in which the blepharoplasts were so close together as in *figs. 23* and *24*.

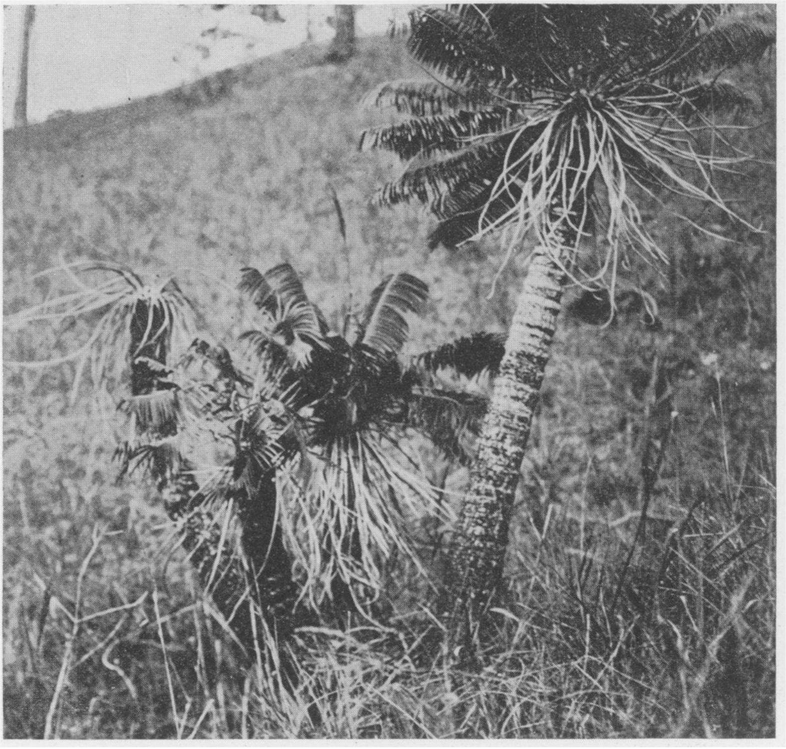


FIG. 5.—Four plants which have grown from stump of an old plant; an exposed grassy hillside.

The division of the body cell (*fig. 25*) results in the formation of two sperm mother cells, which become separated by a definite wall (*fig. 27*). While this division is occurring, the blepharoplasts begin to form a distinct band (*fig. 25*); later this band may become broken up into fragments or small granules, upon which the beginnings of the cilia may be seen (*fig. 27*). The mother cell does not become spherical, but is flattened on the side adjoining its mate, and when somewhat older than the stage shown in *fig. 27* is distinctly beaked at the end, where most of the blepharoplast granules lie. This nuclear beak is described for Cycas by IKENO (7), but according to WEBBER'S figures it does not occur in Zamia. The sperm cells nearly always

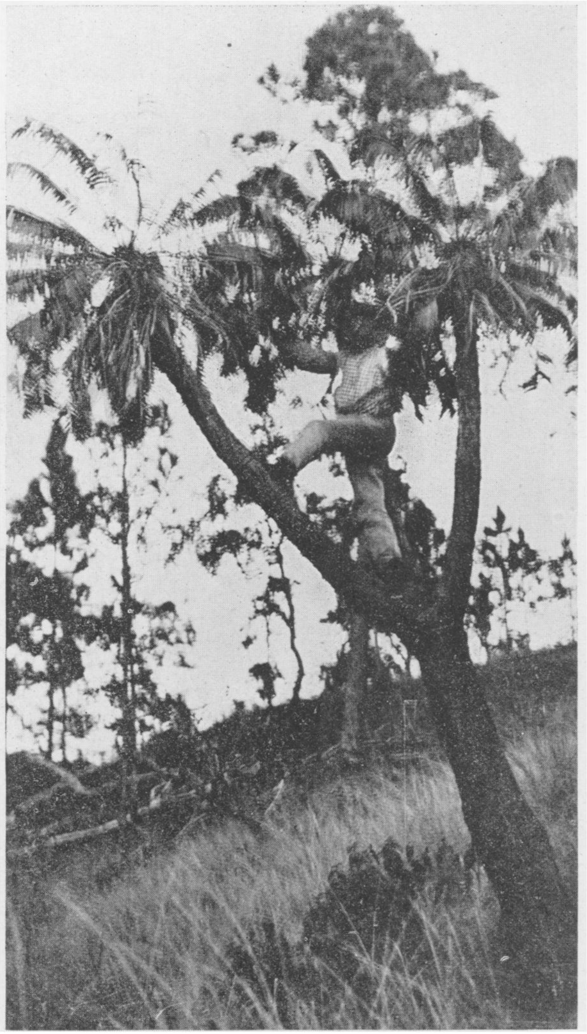


FIG. 6.—A tall branching plant growing in the open and having much the same form as those found in densely shaded areas.

become entirely free from one another before the ciliated band is formed. In Zamia WEBBER points out that the ciliated band is formed before the mother cells become separate, and describes one case in which he observed two sperms swimming while yet attached to each other.

In this manner sixteen sperms are formed in each pollen tube (*figs. 28, 29*). In those pollen tubes in which nine or ten (or possibly more) body cells are formed, it is probable that a larger number of sperms is formed, but no case was observed in which there were more than sixteen sperms.

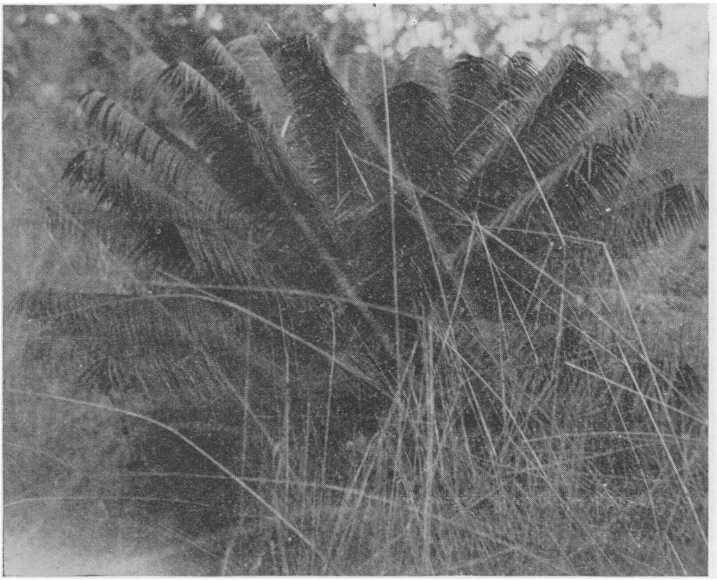


FIG. 7.—A young plant of the type usually found in exposed regions. The crown of such plants suggests that of *Cycas revoluta*.

When the body cells begin to divide to form the mother cells, the tube grows toward the female gametophyte (*fig. 26*). In one case the entire mass of sperms was formed within the thicker portion of the intine, at the point where the pollen tube began to develop from the microspore (*fig. 29*). Whether in this particular case there had been an upward growth of the pollen tube could not be determined. Usu ally the downward growing branch of the tube in which the mass of sperms is found is thin-walled, as are the ascending and lateral branches (*fig. 28*). By dissecting pollen tubes from a cone that had been kept in the laboratory for two months, motile sperms were observed; the general form is shown in *fig. 30*. So far as could be determined, their behavior was similar to that of the sperm described

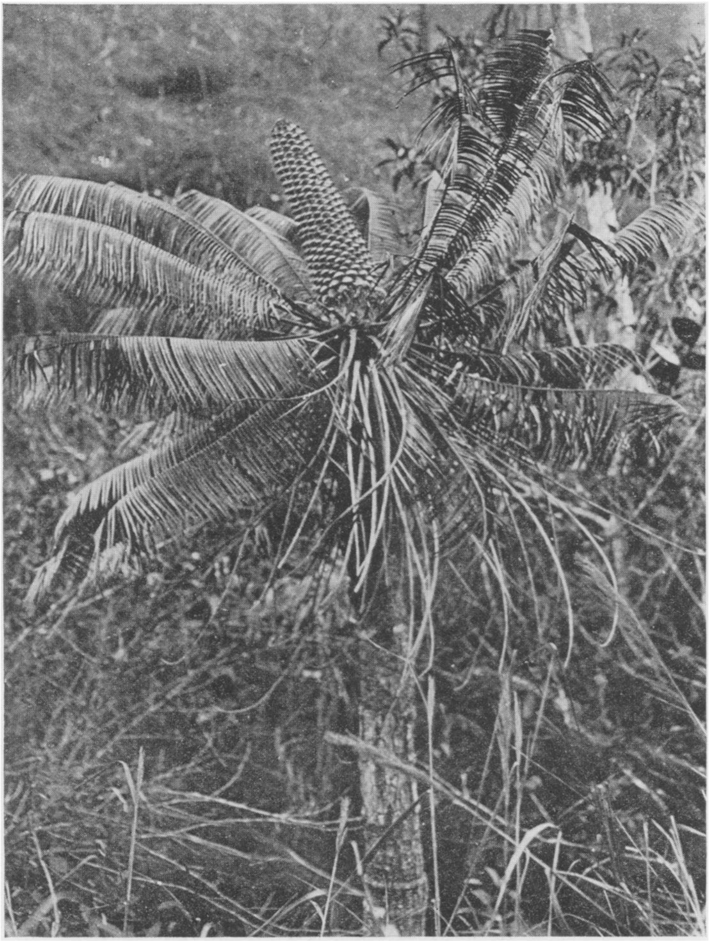


FIG. 8.—An ovulate cone growing upon a plant which stands in a ravine.

for Cycas by IKENO, for Ginkgo by HIRASÉ (8), for Zamia by WEBBER, and for Stangeria by LANG (9). The cone had lost its vigor, however, and no cases of fertilization were secured.

The full significance of this remarkable number of sperms in each male gametophyte cannot be known without an investigation of the origin of the body cells. No other seed-plant has been found to have more than two male cells in each male gametophyte. The fact that there are in Microcycas sixteen mother cells, each organizing a sperm, is especially suggestive when it is recalled that a common number of sperms in each antheridium of the leptosporangiate ferns is thirty-two. Another division of the body cells of Microcycas would result in this fern condition. It will be of great interest to know whether any of the four cycad genera as yet uninvestigated possess this remarkable character.

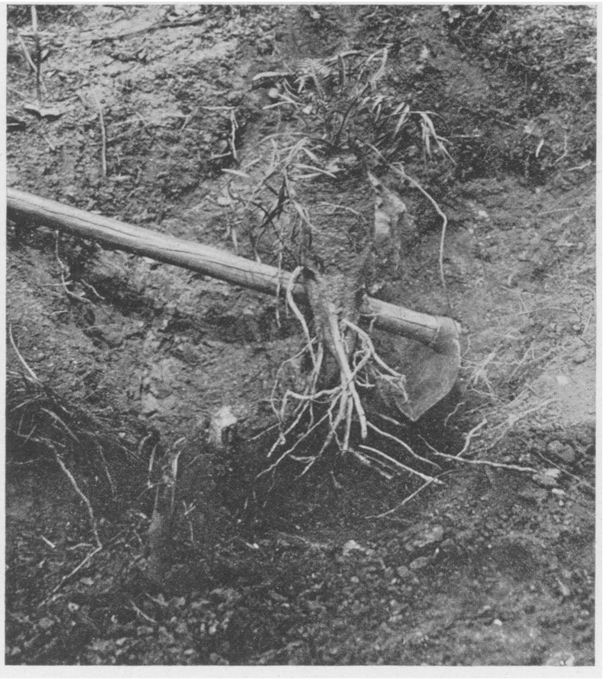


FIG. 9.—A relatively young plant removed from the earth.

FEMALE GAMETOPHYTE AND ARCHEGONIA

None of the material was sufficiently young to show stages in the development of the female gametophyte. The structure of the adult gametophyte, however, shows that tissue-formation proceeded in the usual centripetal manner. Usually the radial arrangement of the cells is quite evident (*fig. 48*), and in nearly all cases there is a median line formed by the abutting tissues (*fig. 50*); in some cases this median cleft extends to the micropylar end of the gametophyte. On the surface of the gametophyte the tissue often produces lobes, between which there may be conspicuous seams of more or less completely united tissues running well into the interior of the gametophyte (*fig. 50*). It seems probable that these lobes continue to grow outward after the main body of the gametophyte is well formed. The cells of the gametophyte are well filled with starch. The entire structure

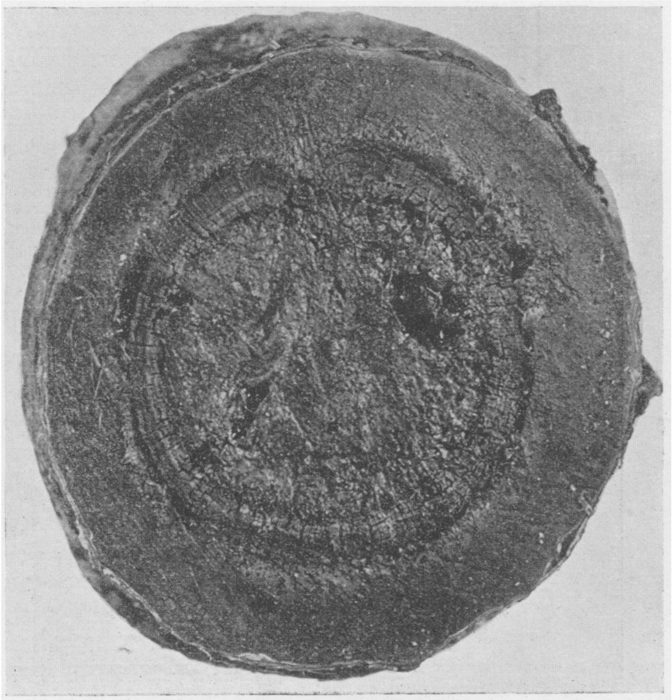


FIG. 10.—Cross-section of stem.

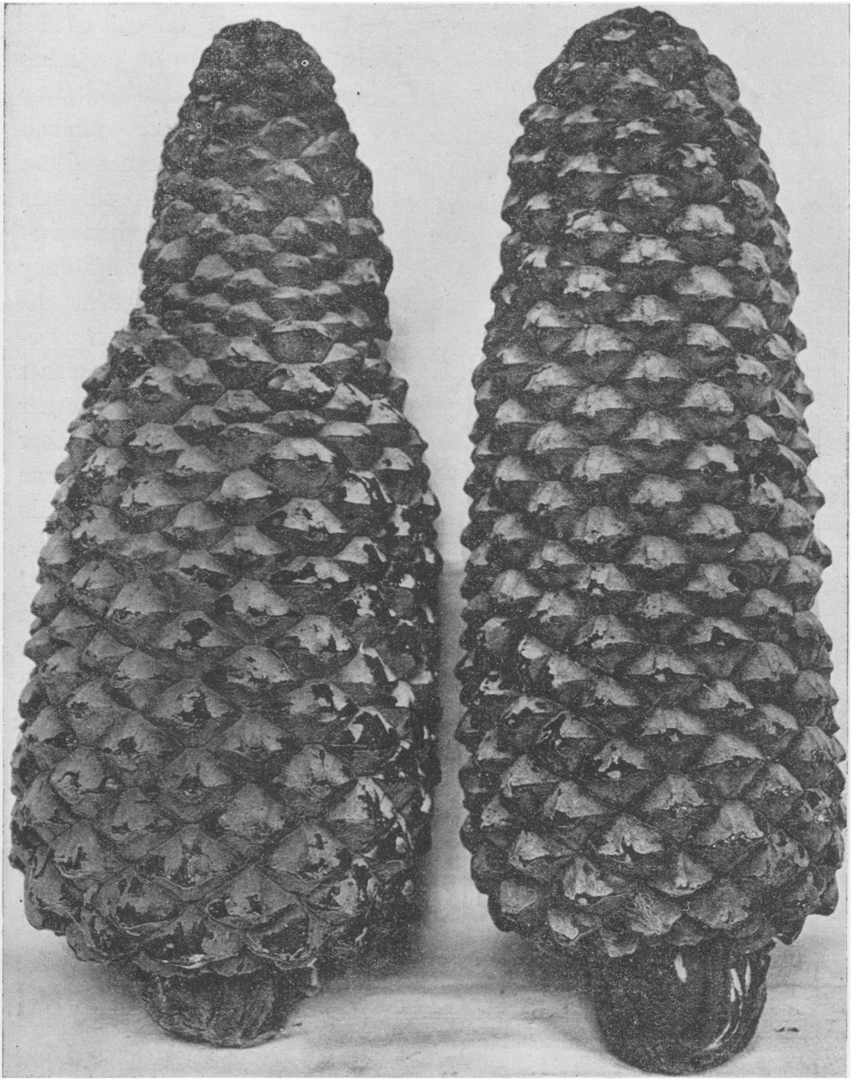


FIG. 11.—Two ovulate cones.

is 2.5–3.5^{cm} long and 1.75–2^{cm} broad. The nucellus forms an extremely thin layer closely adhering to the surface of the gametophyte.

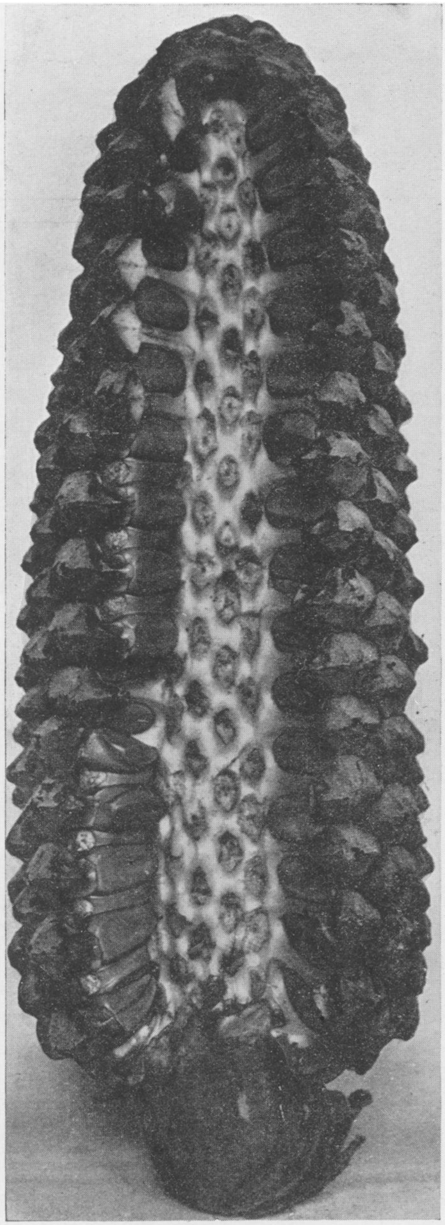


FIG. 12.—An ovulate cone; some of the sporophylls have been removed, showing the central axis and the attachment of the ovules.

Archegonia may be formed at the micropylar end of the gametophyte, or on the lobes produced on the sides or lower end, or on the unlobed surface, or in rare cases within the tissues in such position as to open to the median cleft (*figs. 32, 48, 49, 50*). They are more abundant at the micropylar end than elsewhere, and in many cases they are formed in no other region (*fig. 48*). The number of archegonia is large; one cross-section made a little back of the end of the gametophyte showed 169 distinct archegonia. Doubtless in many cases the number exceeds 200 in the entire gametophyte and may even be double that number (*fig. 49*). There is apparently little difference in the age of archegonia at the micropylar end and on the lateral lobes.

The age of the material did not permit a study of the development of the archegonium. Two neck cells are formed, but these do not protrude as noted in Zamia by COULTER and CHAMBERLAIN (**10**), and in Dioon by CHAMBERLAIN (**4**); they may extend slightly beyond the surface of the gametophyte (*fig. 33*), but usually they are even with the surface, as shown in the case of the single neck cell in *fig. 34*. In some cases at least, the neck cells break down, leaving the central cell exposed at the surface of the gametophyte (*figs. 35, 36*). The contents of the archegonia showed considerable variation. In such archegonia as are shown in *figs. 33* and *34*, there is the usual condition in which the ventral canal cell has not yet been cut off; in numerous other cases, however, two or three nuclei were found (*figs. 36, 37, 39*). COKER (11) found that in Taxodium the free ventral canal nucleus after fertilization divides amitotically; and in Podocarpus he observed (12) the same phenomenon. It is possible that some of the nuclei found in the archegonium of Microcycas may have arisen in this way, but failure to find any ventral canal nuclei in the usual position, though many central cells were examined, indicates that the material was not old enough to have formed ventral canal cells. That some of the central cells were almost ready to divide, hower, is shown by the condition of the nuclei in *figs. 34* and *35*. It is probable that archegonia may unite by the absorption of their dividing walls, for they often crowd upon one another very closely, as in *fig. 38*, in which absorbtion of the separating walls would result in just such a condition as is shown in *figs. 36, 37*, and *39*. Comparison with other cycads would also suggest that the archegonium has not reached the stage for cutting off the ventral canal nucleus. It seems altogether probable that a ventral canal nucleus is cut off subsequently, and that the two or more free nuclei observed are the result of the union of two or more archegonia.

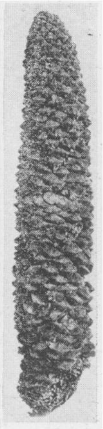


FIG. 13.—An old staminate cone.

The development of jacket cells, as described by GOROSCHANKIN (13), TREUB (14), IKENO (7), SMITH (15), STOPES and FUJII (16), is much less regular in Microcycas than in the other cycads studied. This is probably due to the crowding together of archegonia and the consequent absorption of intervening tissue.

The very large number of archegonia and their peculiar distribution are suggestive of primitive conditions, and this is emphasized by association with the large number of sperms.

EMBRYO

From the material collected during January and February no cases of fertilization or young embryos were found. A second collection of cones forwarded late in February failed to arrive. In a third collection, which was shipped from Cuba early in April, the ovules were found to contain embryos in which the suspensors were well developed. The suspensors are long and more or less spirally coiled (*figs. 40, 41*), the one shown in *fig. 41* being 8^{cm} long. A dozen or more embryos may be found in a single gametophyte. The pressure of the spiral suspensor is such as frequently to lift the nucellar cap when the hard seed coat is removed. Such a pressure on the embryo would hold it firmly against the endosperm. Frequently suspensors pass upward through the archegonia and over the gametophyte under the nucellar cap (*fig. 41*). No embryos were found in any archegonia except those at the micropylar end of the gametophyte.

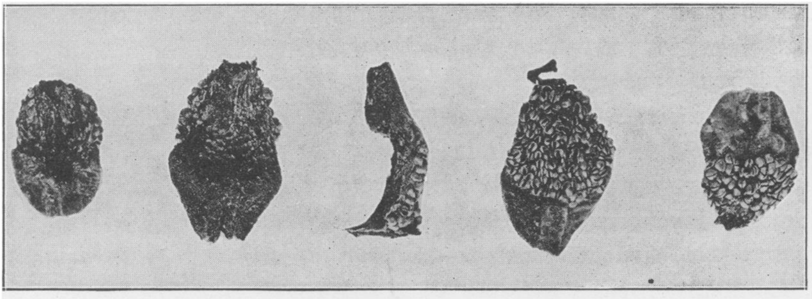


FIG 14.—Staminate sporophylls; the two at the left show the adaxial surface, the two at the right the abaxial surface, the middle one a lateral view.

While material was being collected in January and February, seeds were found on the ground at the bases of plants that had ripened ovulate cones the preceding year, and some of them had germinated. The fleshy seed coat was gone, and in many cases there were scars upon the hard seed coat, evidently made by the teeth of animals; in some cases the empty seed coat appeared to have been opened by animals.

Within the mature seed a single large straight embryo extends along the median axis. One-half is made up of the cotyledons, those in the seeds examined varying from three to six in number; usually they are straight, but occasionally they are spirally twisted (*fig. 42*). The seeds and seedlings secured were planted in the greenhouse and are just now beginning to grow. After the root tip emerges and enters the earth (*fig. 43*), the cotyledons remain in the seed coat for a long period, but its length was not determined. A tuberous stem several centimeters in length is produced before other structures emerge from the seed. The first true leaf, just now appearing in the greenhouse material, is somewhat circinate, distinctly hairy, and arises almost from the center of the stem (*figs. 44, 45*). In the peculiarly severe conditions in which Microcycas lives, there is often great danger to the seedlings of dessication, and the production of a stout tuberous stem before the production of leaves is evidently of great advantage.

SUMMARY

1. Small and widely separated groups of *Microcycas calocoma* occur in some of the mountains of western Cuba.

2. The adult plant is a small tree, and reaches the greatest height and circumference yet recorded for any cycad indigenous to the western hemisphere. The stem may be a straight shaft or may branch many times.

3. The ovulate cone is the largest known; and it and its sporophylls bear more resemblance to those of Zamia than to those of other cycads.

4. Unbranched vascular bundles pass up the stalk of the megasporophyll, anastomose in the expanded portion, then give off five to eight branches to each ovule. Immediately after entering the ovule each branch divides, one subdivision passing unbranched through the fleshy layer, and the other passing into the hard layer and branching many times.

5. The staminate cone is long and slender, and two-thirds of the abaxial side of its sporophylls is densely covered by sporangia which do not show any distinct grouping into sori.

6. In the male gametophyte eight body cells are formed and sixteen sperms. Each body cell has two large blepharoplasts which usually lie on opposite sides of the cell, but sometimes may lie side by side. Sometimes nine or ten body cells are produced.

7. The female gametophyte is often prominently lobed, and develops a large number of archegonia (sometimes exceeding 200), which are produced on any part of the surface or even within the endosperm.

8. Many embryos are produced, the suspensor being very long and spirally coiled and pressing the embryo tip against the endosperm; the cotyledons are three to six in number.

9. Microcycas may be regarded as the most primitive cycad yet described.

I wish to acknowledge the kindly assistance in the field and in camp from Señor DON FELICE HERNANDEZ Ŷ CRUZ of Santa Catalina, Cuba; assistance in the field and courtesies in the laboratories of the Cuban Agricultural Experiment Station from Professor C. F. BAKER, Director J. T. CRAWLEY, Mr. H. A. VAN HERMANN, and Mr. E. W. HALSTED; and courtesies of the laboratories, constant suggestions, and helpful criticism from Professor JOHN M. COULTER and the members of the botanical staff of The University of Chicago.

THE UNIVERSITY OF CHICAGO

LITERATURE CITED

1. CALDWELL, O.W., and BAKER, C. F., The identity of *Microcycas calocoma.* BOT. GAZ. **43**:330–335. *figs. 3.* 1907.
2. MIQUEL, A. F. W., Sur une espèce nouvelle de Zamia des Indes occidentales, introduite dans l'établissement Van Houtte, à Gand. Van Houtte's Fl. Serres et Jard. **7**:141. 1851.
3. DECANDOLLE, A., *Microcycas calocoma.* DC. Prodr. **16**^{2}:538. 1868.
4. CHAMBERLAIN, C. J., The ovule and female gametophyte of Dioon. BOT. GAZ. **42**:321–358. *pls. 13–15. figs. 1–9.* 1906.
5. STOPES, M. C., On the double nature of the cycadean integument. Annals of Botany **19**:561–566. 1905.
6. WEBBER, H. J., Spermatogenesis and fecundation of Zamia. Bull. 2, U. S. Bureau of Plant Industry. pp. 100. *pls. 6.* 1901.
7. IKENO, S., Untersuchungen über die Entwickelung der Geschlechtsorgane und der Vorgang der Befruchtung bei *Cycas revoluta.* Jahrb. Wiss. Bot. **32**:557–602. *pls.* 8–10. 1898.
8. HIRASÉ, S., Études sur la fécondation et l'embryogénie du *Ginkgo biloba.* Jour. Imp. Coll. Sci. Tokyo **8**:307–322. *pls. 31–32.* 1895.
9. LANG, W. H., Studies in the development and morphology of cycadean

sporangia. II. The ovule of *Stangeria paradoxa.* Annals of Botany **14**: 281–306. *pls. 17–18.* 1900.

10. COULTER, J. M., and CHAMBERLAIN, C. J., The embryogeny of Zamia. BOT. GAZ. **35**:184–194. *pls. 6–8.* 1903.
11. COKER, W. C., On the gametophytes and embryo of Taxodium. BOT. GAZ. **36**:1–27, 114–140. *pls. 1–11.* 1903.
12. ———, Notes on the gametophytes and embryo of Podocarpus. BOT. GAZ. **33**:89–107. *pls. 5–7.* 1902.
13. GOROSCHANKIN, J., Zur Kenntnis der Corpuscula bei den Gymnospermen. Bot. Zeit. **41**:825–831. *pl. 70.* 1883.
14. TREUB, M., Recherches sur les Cycadées. 3. Embryogénie du *Cycas circinalis.* Ann. Jard. Bot. Buitenzorg **4**:1–11. *pls. 1–3.* 1884.
15. SMITH, M. ISABEL, The nutrition of the egg in Zamia. BOT. GAZ. **37**: 346–352. *figs. 6.* 1903.
16. STOPES, M. C., and FUJII, K., The nutritive relation of the surrounding tissues of the archegonia in gymnosperms. Beih. Bot. Centralbl. **20**:1–24. *pl. 1.* 1906.

EXPLANATION OF PLATES X–XIII

PLATE X

FIG. 15. Diagram of nucellus showing haustorial branches of pollen tubes growing upward and outward from pollen chamber. ×15.

FIG. 16. Diagram of megasporophyll showing anastomosing of veins in expanded portion; veins passing into ovule and rebranching at base of ovules into outer fleshy and stony layers: *g*, female gametophyte; *n*, nucellus; *i*, stony layer; *v*, unbranched vascular bundle in fleshy layer (*o*); v^1, branching vascular bundles in stony layer. ×$\frac{2}{5}$.

FIG. 17. Pollen tube containing eight body cells, some of which show two blepharoplasts; one small tube nucleus; stalk cell and projecting into it the prothallial cell; a fragment of the exine adheres to the intine at the base of the tube. ×160.

FIG. 18. Pollen tube with eight body cells, tube nucleus, stalk cell, and prothallial cell. ×160.

FIG. 19. Pollen tube at left of *fig. 15;* contains ten body cells and the other structures shown in *figs. 17* and *18.* ×160.

FIG. 20. Pollen tube containing nine body cells. ×160.

PLATE XI

FIG. 21. Body cell surrounded by thin layer of cytoplasm; blepharoplasts at opposite ends of the cell; nucleus apparently compressed by radiating fibers; prominent nucleolus. ×750.

FIG. 22. Blepharoplasts on same side of body cell. ×1400.

FIG. 23. Blepharoplasts near one another. ×1400.

FIG. 24. Blepharoplasts in contact. ×1400.

FIG. 25. Spindle in body cell, showing some of the chromosomes; blepharoplasts beginning to form band. ×750.

FIG. 26. Diagram of nucellus showing several pollen tubes; lowest one showing the descending portion in which the sixteen sperms are formed. ×15.

FIG. 27. Pair of mother cells formed from body cell; near wall may be seen fragments of blepharoplasts. ×750.

PLATE XII

FIG. 28. Descending tip of pollen tube in which are fifteen sperms in process of formation; top of spiral of one is shown, and the beginnings of spiral bands in two others; to the left is the tube nucleus. ×450.

FIG. 29. Pollen tube containing sixteen sperms, two of which show merely the tip of their spiral bands; it was not possible to discover in this tube the usual haustorial branch that ascends into the nucellus, all development having apparently taken place almost within the limits of the old microspore; intine unusually heavy and somewhat broken; growth in the direction of the archegonia. ×180.

FIG. 30. Sperm seen from above. ×750. (Plate XI.)

FIG. 31. Part of ciliated band showing two regions and cilia arising from darker one. ×1400.

FIG. 32. Diagram of cross-section of ovule, made from cross-section about one-third its length from micropylar end. ×3.

FIG. 33. Diagram of an archegonium. ×75.

FIG. 34. Archegonium, showing central cell and one neck cell.

FIG. 35. Tip of archegonium; neck cells absent or broken down. ×750.

FIG. 36. Archegonium containing three nuclei, probably resulting from union of three archegonia; neck cells absent or broken down. ×750.

FIG. 37. Archegonium containing three nuclei, probably resulting from union of three archegonia. ×270.

FIG. 38. Diagram of section of two archegonia, the two having the form of one, but still separated by wall. ×270.

FIG. 39. Cross-section of an archegonium containing two nuclei. ×270.

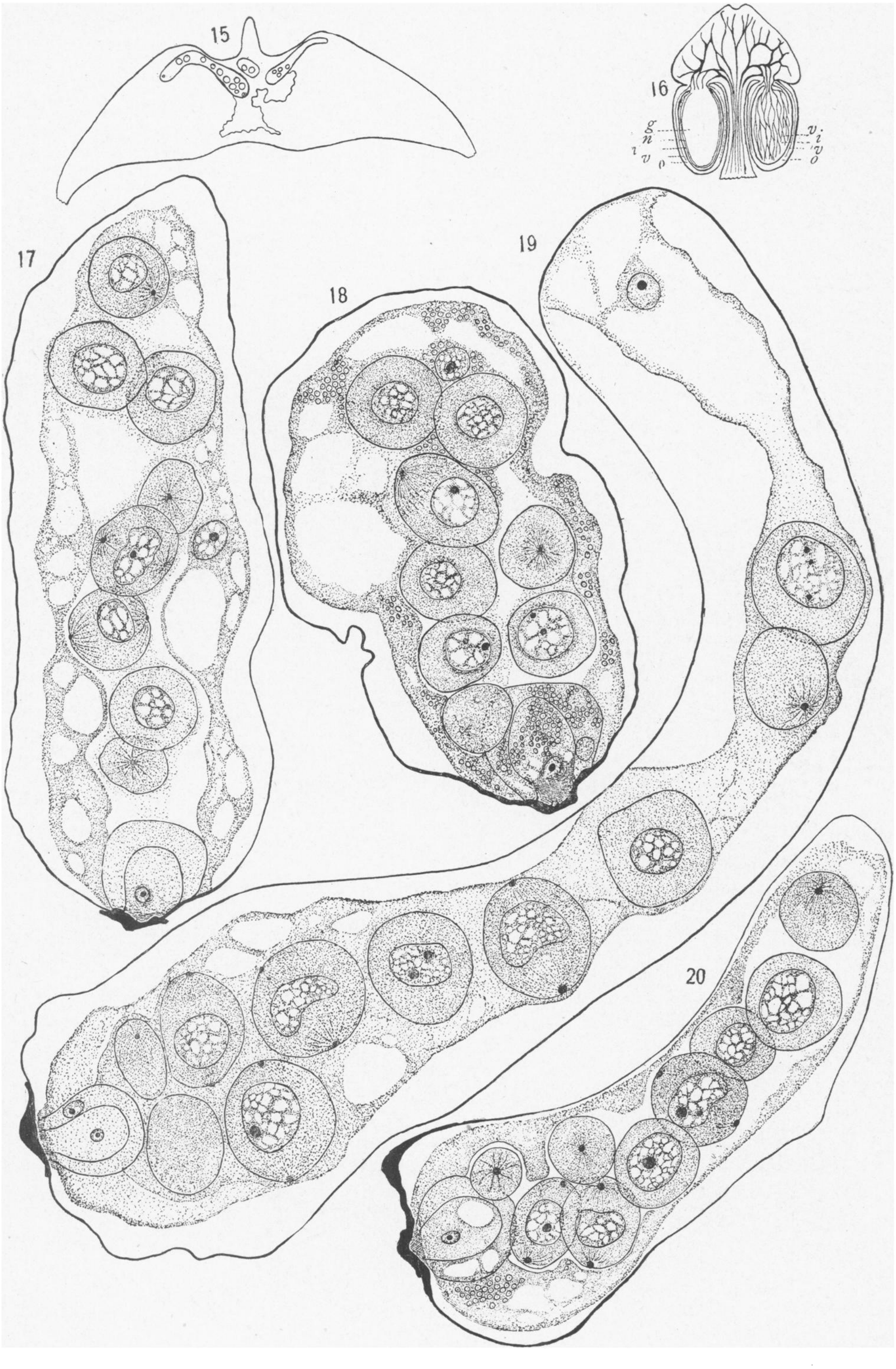
FIG. 40. Two young embryos, their suspensors so closely attached as to be indistinguishable above, but separated below; at top is mass of old archegonia from one of which the embryos are growing. ×2.

FIG. 41. Older embryos growing from mass of old archegonia; the longest suspensor measured 8^{cm} in length; two suspensors growing upward from the archegonia were closely appressed to the gametophyte immediately beneath the nucellar cap. ×½.

FIG. 42. Endosperm (seed coats removed) containing an embryo; cotyledons spirally twisted, a feature not present in most seeds examined. ×½.

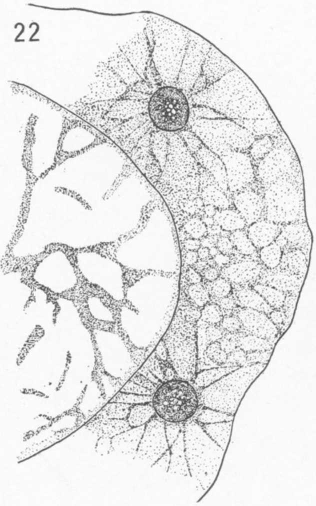
FIG. 43. Germinating seed. ×½.

FIG. 44. Young plantlet resuming growth after having been transplanted; stem in same position as found in nature; at its top are scale-like growths which

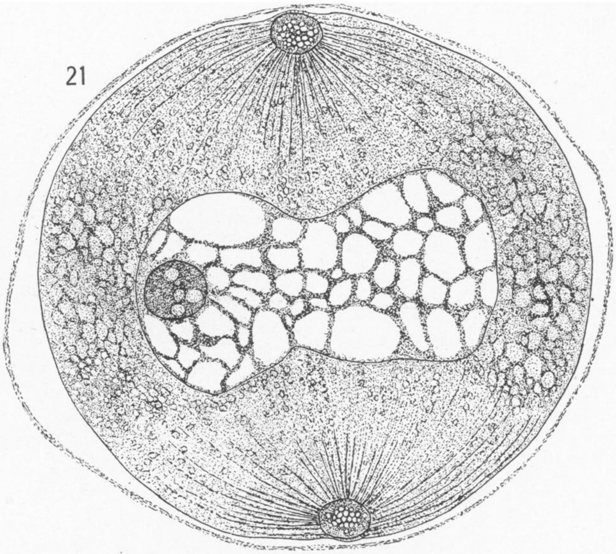


CALDWELL on MICROCYCAS

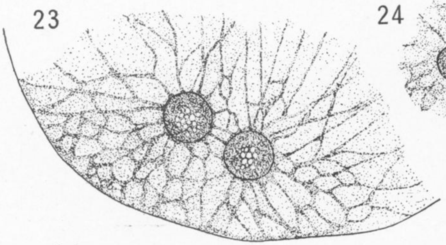
22



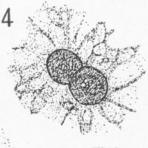
21



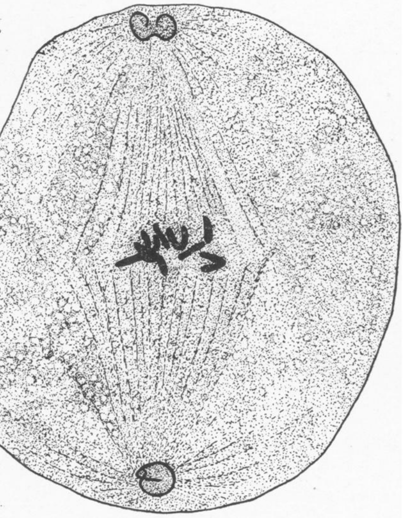
23



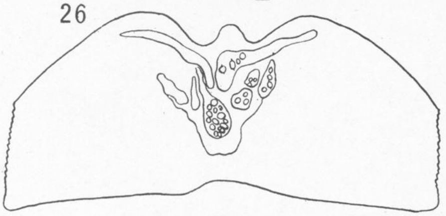
24



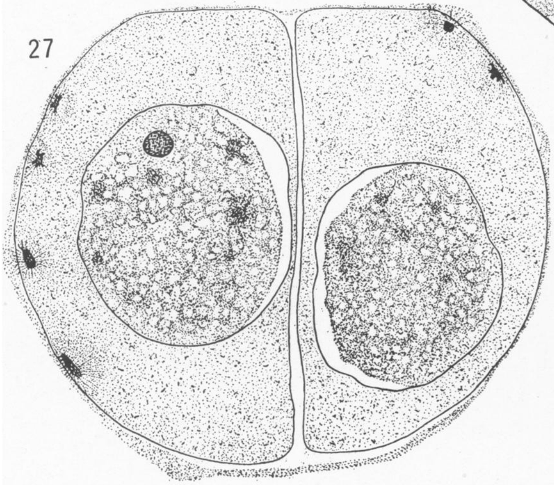
25



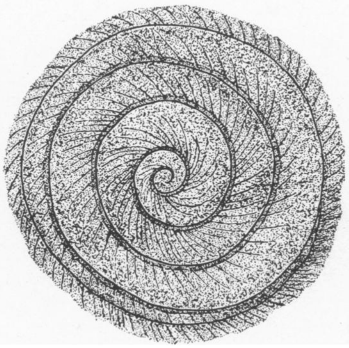
26



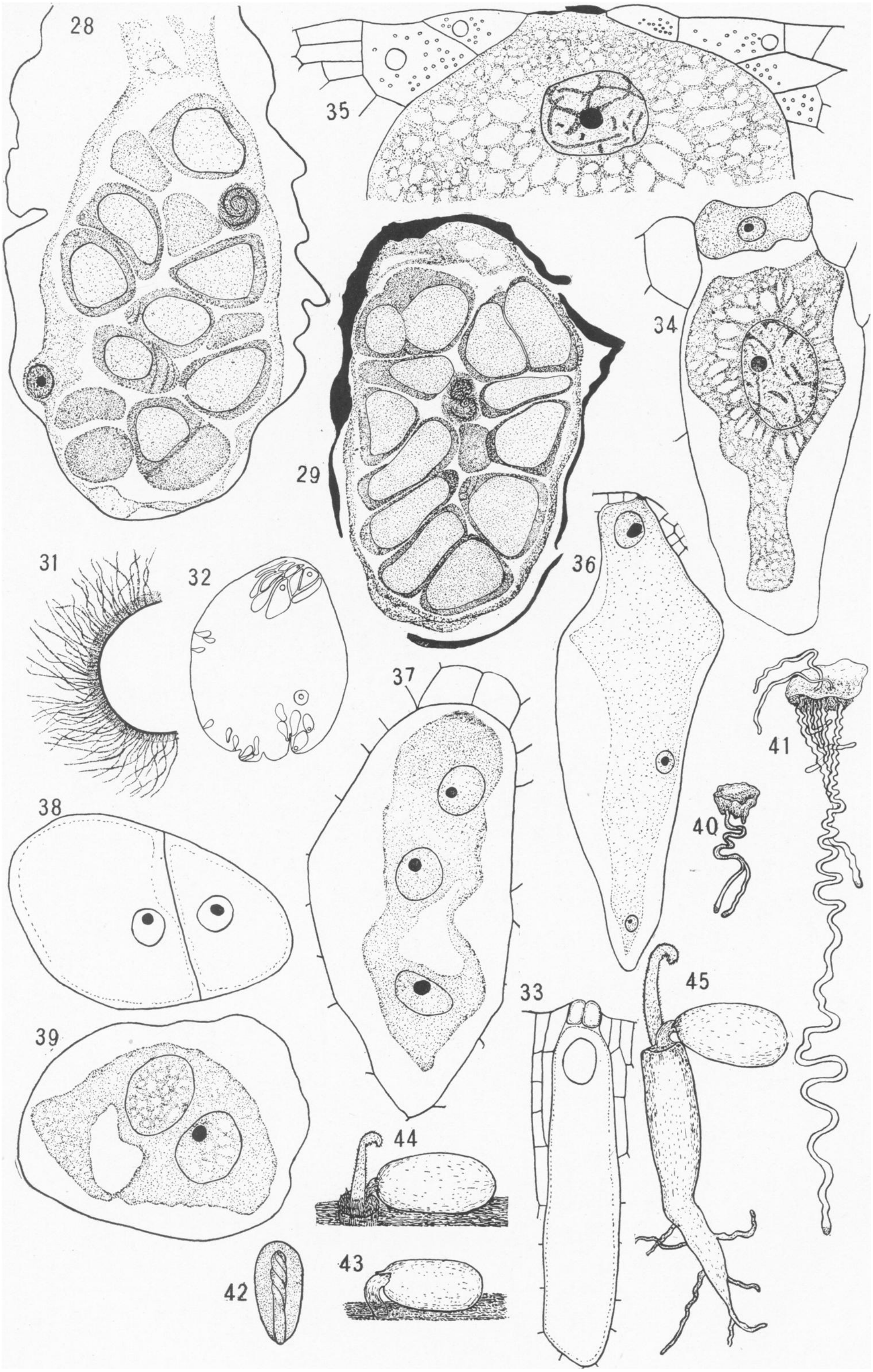
27



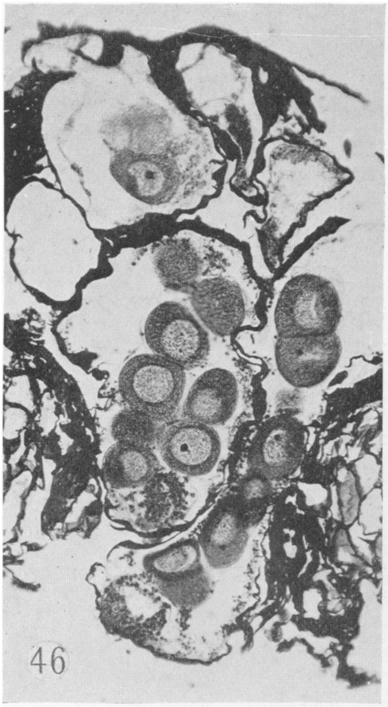
30



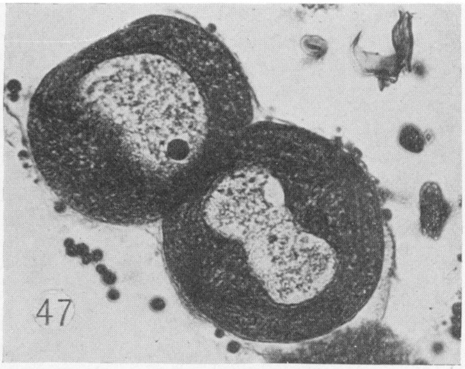
CALDWELL on MICROCYCAS



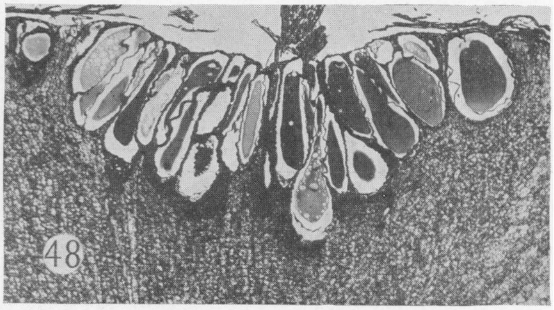
CALDWELL on MICROCYCAS



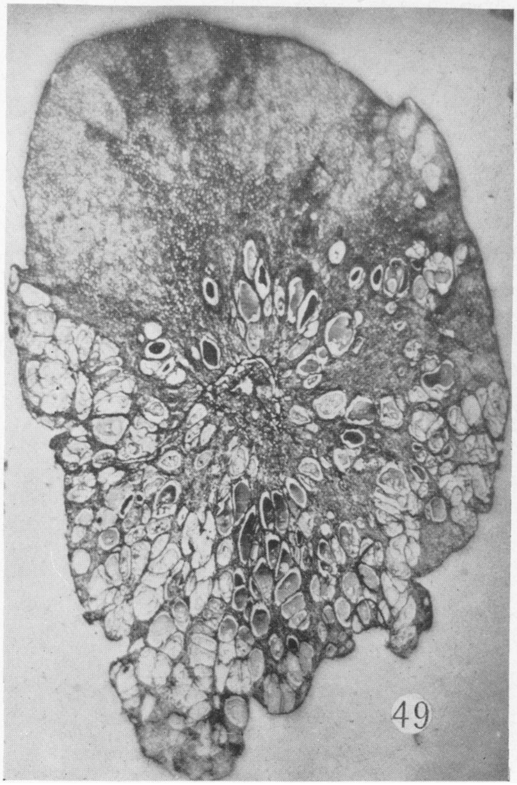
46



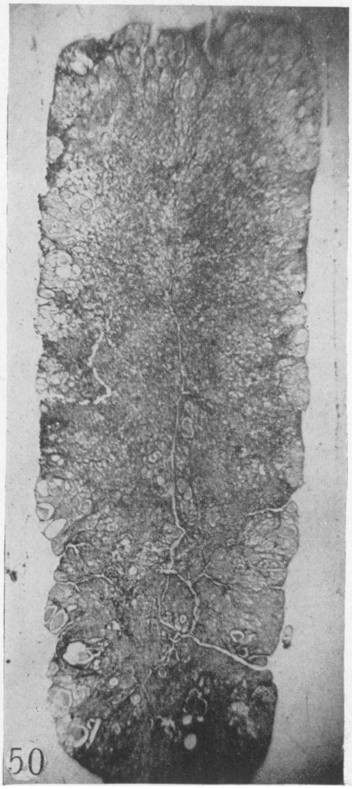
47



48



49



50

CALDWELL on MICROCYCAS

apparently are beginnings of bud scales; first leaf circinate, distinctly hairy, and showing the beginning of leaflets. ×½.

FIG. 45. Plantlet, of same age as in *fig. 44*, removed from the earth; does not show scale-like growths. ×½.

PLATE XIII

FIG. 46. Pollen tubes in nucellus; body cells (eight in each of two tubes) seen in the ascending haustorial branches.

FIG. 47. Two body cells, showing form of nucleus, blepharoplasts, and radiating cytoplasm.

FIG. 48. Tip of female gametophyte, showing mass of archegonia.

FIG. 49. Cross-section of female gametophyte about 3^{cm} from micropylar end.

FIG. 50. Longitudinal section of female gametophyte, showing archegonia at micropylar end, along both sides, in median line, and at basal end.